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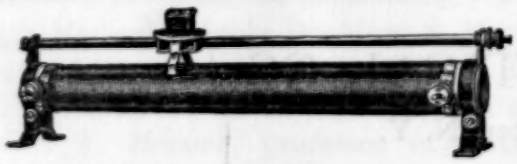

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Science News x

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SOME EFFECTS OF THE ATMOSPHERE UPON PHYSICAL MEASUREMENTS[1]

IT has, I believe, been the custom for the retiring vice-president to address the section either upon the subject of his own research interests or upon recent progress or problems connected with some special field of his science. With your permission, I will to-day depart from this custom by adopting the rôle of a revivalist and delivering an exhortation. In one respect at least I feel that I possess the necessary qualifications for the part, since it is well recognized that the most effective exhorters are those repentant sinners who know, from personal experience, whereof they speak.

I take, as my text, the evil influences of a vagrant atmosphere upon physical measurements. This requires some explanation since the term atmosphere has several different connotations.

In the first place, we have that somewhat vague and impalpable atmosphere which is determined by the intellectual conditions surrounding an investigator and is ordinarily referred to as the research atmosphere of the institution.

Secondly, we have the insidious influences of meteorological conditions, temperature, barometric pressure and humidity, upon the physical and mental well-being of an observer and hence upon his ability to make accurate and trustworthy observations.

Thirdly, these same insidious influences frequently affect the properties of materials to an extent sufficient to cause the measuring instruments of the investigator to behave in a way no self-respecting piece of apparatus should and he is consequently put to all kinds of trouble in his efforts to combat them.

Each of these various types of atmospheric influences is important enough to be worthy of an essay, but none of them forms the topic of to-day's sermon. Instead, I shall direct your attention to certain effects of the physical atmosphere which sometimes result in causing an investigator to be under the delusion that he is measuring or utilizing one quantity when as a matter of fact he is dealing with something, not greatly perhaps but still appreciably different. I do not expect to tell you anything new. No revivalist in good standing would be expected to do that. In so far as any of us may have been guilty of backsliding it is because we have been immoral, not unmoral;

[1] Address of the vice-president and chairman of Section C—Chemistry, American Association for the Advancement of Science, Washington, D. C., December, 1924.

we knew better, but we "didn't think." Let me warn you in advance that I shall divide my subject into a firstly, a secondly, etc., up to a ninthly and lastly, so that as we progress you may have some idea of how long-drawn-out this sermon is going to be and can govern yourselves accordingly. At the end of the sermon, however, no collection will be taken up.

The presence of the atmosphere in contact with a substance or system which is being subjected to quantitative investigation affects the situation in two ways which we shall designate, respectively, as (1) the direct-pressure effect, and (2) the air-solubility effect. As a result of the first of these effects the system is studied under a condition of uncontrolled (but of course not necessarily unknown) external pressure which varies with time and with location on the earth's surface. In other words, different determinations of the same property of a given system under "atmospheric" pressure are not necessarily comparable. In the case of gaseous systems this effect is of course very pronounced and no trouble is experienced in such cases, since the precautions or corrections necessary to obtain comparable results are always taken care of. With liquids and solids, on the other hand, the effect is so much smaller that it is usually neglected, although not always negligible.

The second effect, that due to the presence of dissolved air in the system, in contrast to the first effect, changes the nature of the system rather than merely its condition. This effect is too often entirely neglected by investigators without taking the trouble to ascertain its magnitude or even to insure its constancy.

(1) Chemical Analysis

The direct-pressure effect.—In computing the results of a chemical analysis, the analyst makes use of certain factors which are stoichiometrically calculated from atomic weights. Since atomic weights are based upon experiments in which the buoyant effect of the atmosphere has in all cases been corrected for, it is evident that analytical factors are likewise all upon the *"in-vacuo"* basis. In ordinary chemical analysis, however, the vacuum correction is seldom made; that is, all the weighings made during the course of the analysis represent weights-in-air. Consequently, when these weighings are combined with the analytical factors in computing the result of the analysis in the form desired, the result obtained is a hybrid quantity, since it is based neither upon *weights-in-vacuo* (true mass) nor upon weights-in-air. Moreover, two analysts working under different meteorological conditions will not only both obtain incorrect results, but their results will not agree, owing to the variability in the buoyant effect of the atmosphere with meteorological conditions.

At this point let me hasten to say, however, that this source of error in analytical chemistry, while theoretically existent, is of no practical importance except in analytical work of very high precision, and usually then only in the case of analysis which involves the weighing of one material or substance of low density (1 or less) and another of high density (5 or more). The magnitude of the errors which can arise under these extreme conditions through failure to reduce all weighings *ad-vacuum* is illustrated by the following tables, which show for three analytical examples (1) the correct result of the analysis, (2) a result which might be obtained by an analyst in Boston and (3) a result which might be obtained by an analyst at Santa Fé (Mexico City; Boulder, Colo.; or Mt. Wilson, Calif.), using the same procedure, if both analysts neglected to reduce their weighings *ad vacuum*.

I. Determination of chlorine in an organic liquid ($d = 0.7$) by weighing as AgCl.

True per cent.	Boston	Santa Fé
10.0000	10.0157	10.0109
Per cent. error	0.16	0.11

II. Solubility of I_2 in a light organic liquid determined by titrating a weighed sample of the saturated solution with a solution standardized against solid I_2.

True per cent.	Boston	Santa Fé
10.0000	10.0155	10.0108
Per cent. error	0.16	0.11

III. Solubility of $PbCl_2$ in H_2O at 0°. Weighed sample evaporated to dryness.

True per cent.	Boston	Santa Fé
0.6700	0.6693	0.6695
Per cent. error	0.10	0.07

From these illustrations, the following conclusions may be drawn:

(1) If the accuracy of the method justifies the use of more than four significant figures in reporting the result, the analyst should compute the magnitude of the correction for the buoyant effect of the air, and should reduce all his weighings *ad vacuum*, if this effect is significant.

(2) If the accuracy of the method justifies the use of five significant figures in reporting the result, the vacuum correction should always be made; but if the laboratory is located at a high altitude, this correction should not be taken directly from the tables given in handbooks for this purpose, since these tables have been computed for average meteorological conditions at sea-level.

Whenever an investigator takes the trouble to make a weighing to a precision of 0.05 per cent. or better,

the additional trouble of recording the barometric pressure and the temperature of his balance case is worth while, and, unless the balance case contains a drying agent, a psychrometer record may also be useful in some cases of high precision work. The habit of recording these observations in the note-book is a good one to acquire, even though they may not be needed in the majority of cases.

The air-solubility effect.—The effect of dissolved air upon the weight of a substance is usually very small in the cases of liquids and will be discussed in section 9 below. In the case of solids, however, it is sometimes of great importance, especially when the solid is in a finely powdered or colloidal condition so that it exposes a large surface to the atmosphere. Such solids after drying and cooling in an atmosphere of dry air are customarily weighed in closed tubes to prevent the adsorption of moisture from the atmosphere. The avidity for moisture displayed by some materials ordinarily not considered as especially hygroscopic is sometimes astonishingly great when they expose a large surface to the atmosphere. Thus a perfectly dry clay brick will gain in weight if placed in a desiccator over calcium chloride or 1.84 sp. gr. sulphuric acid. A similar behavior has been reported by Hillebrand[2] in the case of a powdered mineral which, after dehydrating at 280°, gained 1½ per cent. on standing over sulphuric acid.

The adsorption of dry air by such materials is usually not sufficient to be significant, but in certain extreme cases and where a high degree of accuracy is sought, the possibility of such adsorption should be investigated. One extreme case of this kind has been reported by Friedel,[3] who states that certain zeolites and chabozites will adsorb up to 1.8 per cent. of their own weight of "dry" air.

(2) The Thermometric Ice Point and Other Freezing Points

The thermometric ice point is defined[4] as the "temperature of melting ice." Although not so stated in the official wording of the definition of the fundamental interval, it is usually understood that the melting ice shall be under a pressure of one "normal atmosphere." Even with this additional specification, however, the definition fails to define a definite temperature, the uncertainty being something less than 0.0024° C., depending upon whether the water is free from or saturated with air. The definition might be made perfectly definite by wording it in any of the following ways:

(1) The thermometric ice point is the temperature at which pure ice is in equilibrium with pure air-free water when both phases are under a pressure of one normal atmosphere and the surface of contact is a plane;

(2) The thermometric ice point is the temperature at which pure ice is in equilibrium with pure water saturated with pure air at the same temperature, and at the pressure p_A where $p_A + p_w$ equals one normal atmosphere, p_w being the vapor pressure of ice under these conditions, and both the ice and the solution being consequently under a pressure of one normal atmosphere) and the surface of contact is a plane; or

(3) The thermometric ice point is the temperature of the triple-point, Ice I-liquid-vapor, for the system H_2O.

The conditions corresponding to any one of these definitions might be realized experimentally, but those corresponding to the second definition are perhaps the most convenient for everyday use. They can probably be most conveniently realized,[5] for all present-day purposes, by immersing the thermometer in a stirred mixture of pure water and finely divided ice in a vacuum-jacketed or ice-jacketed vessel, the water being saturated with air by bubbling through it, previous to taking the final reading, a current of pure air, precooled by passing it through a column of ice. The temperature thus obtained requires only to be corrected to the standard barometric pressure whenever this correction is significant. This correction may be computed as follows:

An increase in barometric pressure lowers the temperature of equilibrium between ice and air-saturated water from two causes, (1) the direct effect of external pressure upon the two-phase equilibrium and (2) the indirect effect of an increased amount of dissolved air in the solution. The lowering, $-\Delta t_p$, due to the first effect, is

$$-\Delta t_p = 0.0075° \text{ per atm.} = 0.000099° \text{ per cm of Hg.} \quad (1)$$

The lowering, $-\Delta t_s$, due to the second effect, is

$$-\Delta t_s = 1.86 \times \frac{pv}{RT} = \frac{1 \times 0.0292}{0.08206 \times 273.1} = 0.0024° \text{ per atm.} = 0.0000316° \quad (2)$$

[2] Hillebrand, Geol. Survey Bull. *422*, 69 (1916).

[3] Friedel, *Compt. rend.*, *122*, 1006 (1895).

[4] Resolution of the International Committee on Weights and Measures, October 15, 1887. Bureau of Standards Bulletin *3*, No. 4, p. 664.

[5] Julius Meyer (*Z. physik. chem.* *90*, 722 (1915)) suggests the first definition and proposes to attain the required condition by determining the melting point starting with carefully purified ice and presumably packing the thermometer with this ice and allowing drainage. Constancy of temperature, however, requires equilibrium between the two phases, and the thin film of water covering the surface of this melting ice would probably contain an indefinite amount of dissolved air if in contact with the atmosphere, even though this liquid film were renewed continuously by melting and drainage. The uncertainty arising from this factor, however, could only be determined by experimental investigation.

per cm of Hg where v ($= 0.0292$) is the number of cc (measured at 0°, 760 mm) of dissolved $O_2 + N_2$ in water saturated with CO_2—free air at 0° and 1 atm.[6]

The total correction to take care of barometric influences is therefore given by the equation

$$\Delta t = 0.00013(76 - B) \qquad (3)$$

Thus, if a mixture of ice and air-saturated water at 76 cm has the temperature 0° by definition, the same mixture at a barometric pressure of 58 cm (*e.g.*, at Mexico City; Boulder, Colo.; Mt. Wilson, Calif.; Santa Fé, N. M., etc.) will have the temperature 0.0023°.

It is also obvious that in determining the freezing point lowering of dilute aqueous solutions, where a precision of 0.0001° or better is now attainable, similar precautions to insure either saturation with, or better freedom from, air are necessary since the freezing-point lowering produced by the dissolved air is sometimes a large fraction of the lowering produced by the solute under investigation.

In all determinations of the normal freezing points of pure substances, the uncertainties arising from the presence of the atmosphere must likewise be either eliminated or corrected for as in the case of water. With substances other than water there is, however, also the added complication arising from the presence of aqueous vapor in the atmosphere in variable amounts, thus making it necessary, in many cases, to scrupulously exclude all direct contact with the atmosphere during the measurement. This is necessary even with substances, such as benzene, for example, which are ordinarily considered as non-hygroscopic.

On the other hand, while in the case of the ice point the "direct pressure effect" and the "air solubility effect" act in the same direction and are therefore additive, in the case of most substances the two effects act in opposite directions and therefore tend to neutralize each other. Thus, in the case of benzene, Richards, Carver and Schumb[7] found that the direct pressure effect amounted to $+0.028°$ between the triple point and one atmosphere, while the corresponding air-solubility effect (for dry air) amounted to $-0.031°$.

Hence, although the two separate effects are each very much larger than in the case of water, the net correction, if moisture is carefully excluded, amounts to only 0.003° as against 0.009° in the case of water for the same pressure difference. In other words, a change ¼ atmosphere in barometric pressure would be required in order to change the normal freezing point of benzene by as much as 0.001°.

The same authors studied also the effect of moisture upon the freezing point of benzene and found that an amount of water corresponding to 1 per cent. of saturation was sufficient to lower the freezing point by 0.001°, thus making it necessary to carefully dry the benzene and to exclude all contact with moisture during the temperature measurement. The precautions necessary to realize this condition, while attainable, are, to say the least, bothersome and for this reason the benzene-point is not likely to find great favor as a thermometric fixed point, in spite of its convenient location on the temperature scale and its great constancy with respect to barometric changes.

It seems possible, however, that the 4-phase invariant point, H_2O liq. — C_6H_6 liq. — C_6H_6 crys., under one atmosphere, with complete air saturation, might prove to be an acceptable substitute. At all events, the system seems worthy of investigation in this connection. The temperature of the point should be, according to the data given by Richards and Schumb, about 0.095° below the benzene freezing point.

(3) The Vapor Pressure of a Solid or Liquid

The two methods which have been most frequently employed for measuring vapor pressure are (a) the "static" method and (b) the "dynamic" or "aspiration" method. In comparing the results obtained by the two methods it is not always realized that they do not measure identical quantities. In the static method the quantity measured is the vapor pressure of the liquid or solid phase when under its own vapor pressure. In the dynamic method the liquid or solid phase is usually under atmospheric pressure, and in the case of a liquid, the phase under investigation is not the pure substance but a solution saturated with the gas employed in the experiment, and it is the partial pressure of the substance from this solution which is indirectly measured. The method is indirect because the quantity directly measured is not the vapor pressure but the concentration of the saturated vapor. From this concentration, however, the vapor pressure *under these conditions* is calculable if the equation of state of the vapor is known. Either of these two vapor pressures may be calculated if the other is known, and the difference between them, while small, is by no means insignificant.

The detailed vapor pressure tables for water as given in the various handbooks of physical data, although not always so labelled, represent presumably the vapor pressure of pure water when under its own vapor pressure. If one desires to find from these

[6] The effect produced by the normal CO_2 content of the atmosphere (*i.e.*, 0.004 per cent. by vol.) is only 0.0004° and therefore negligible for all practical purposes. Laboratory fumes are, however, a possible source of error and should be avoided in determinations of the ice point.

[7] Richards, Carver and Schumb, *Jour. Amer. Chem. Soc.* *41*, 2019 (1919).

tables the aqueous tension above water in equilibrium with the atmosphere, it is necessary to add a small correction to the value taken from the table. This correction for any solid or liquid is computed as follows:

(a) The variation of the vapor pressure, p, of a liquid or solid with the external pressure, P, at constant temperature is given by the thermodynamic equation

$$\frac{dp}{dP} = \frac{V_0}{v_0} \tag{4}$$

where V_0 is the volume of one mole of the liquid, and v_0 the volume of one mole of the vapor. Introducing the gas law, $pv_0 = RT$, and integrating gives

$$\log \frac{p}{p_0} = V_0(P - p_0) \tag{5}$$

or with sufficient approximation

$$100\,\frac{p - p_0}{p_0} = 100\,\frac{\Delta p_r}{p_0} = 100\,\frac{V_0}{RT}(P - p_0) \tag{6}$$

where p_0 is the vapor pressure when $P = p_0$.

For a solid, equation (6) gives the total correction factor in per cent. Thus, for example, substituting the numerical data for ice we obtain with sufficient approximation

$$100\,\frac{\Delta p_r}{p_0} = \frac{20}{T} \tag{7}$$

For ice at $-5°$, $p_0 = 3.013$ mm,

$$\frac{100\,\Delta p_r}{p_0} = \frac{20}{268} = 0.075 \text{ per cent.},$$

and hence the vapor pressure of ice in contact with the atmosphere at $-5°$ is 3.015 mm.

(b) In the case of a liquid it is necessary to include in the correction equation a term to take care of the lowering of the vapor pressure due to the solubility, S, of the gas in the liquid. Thus we have

$$S = \frac{C'}{C} \tag{8}$$

where C' is the concentration of the gas in the gas phase, and C its concentration in the liquid. We may write with sufficient approximation

$$C = \frac{C'}{S} = \frac{P - p_0}{SRT} \tag{9}$$

and from Raoult's law

$$\frac{\Delta p_g}{p_0} = x = (\text{approx.})\frac{\frac{C}{1000D}}{M}$$

$$= V_0 C = \frac{V_0(P - p_0)}{SRT} \tag{10}$$

where M is the molecular weight and D the density of the liquid.

Combining this equation with equation (6), we obtain for the net correction, in per cent.

$$100\,\frac{\Delta p}{p_c} = \frac{100V_0(P - p_0)}{RT}\left(1 - \frac{1}{S}\right) \tag{11}$$

which may also be written

$$\frac{100\,\Delta p}{p_0} = \frac{100V_0(P - p_0)}{RT}\left(1 - \frac{\alpha T}{T_0}\right) \tag{12}$$

where α is the Bunsen absorption coefficient.

This equation is applicable to any liquid in contact with a not-too-soluble gas under a not-too-large total pressure P.

It can be put in a convenient form for use by constructing a graph of $\frac{\Delta p}{p_0}$ against t or p_0. If, for example, this is done in the case of water in contact with the atmosphere under a barometric pressure of 760 mm, the graphs obtained can be represented with sufficient approximation by the following empirical equations:

$$100\,\frac{\Delta p}{p_0} = 0.0775 - 0.000313t, \text{ valid up to } 40° \tag{13}$$

and

$$\frac{100\,\Delta p}{p_0} = 0.0652 - 0.0000875p, \text{ valid above } 50° \tag{14}$$

Between 40° and 50° the average from the two equations may be used, t = °C, p = mm Hg.

Table IV below shows the values of p_0 for water at various temperatures, together with the corrections which must be added to these values in order to obtain the vapor pressure above water in equilibrium with the atmosphere. These corrections also represent the difference between the vapor pressures of water, as measured by the static and by the dynamic methods, respectively.

(4) Correction of Boiling Points to Normal Atmospheric Pressure

This correction is usually made with the aid of Craft's Rule, and this method is entirely satisfactory for moderate barometric variations. For boiling points determined at high altitudes or under artificially reduced pressures, however, some more accurate means of computing the normal boiling point is re-

TABLE IV

t° C.	0	10	20	30	40	50	60	70	80	90
p_0, mm Hg	4.579	9.209	17.535	31.824	55.324	92.51	149.38	233.7	355.1	525.76
Δp, " "	0.0036	0.0069	0.0124	0.0217	0.036	0.053	0.078	0.104	0.121	0.102

quired. Mr. C. S. Cragoe, of the U. S. Bureau of Standards, has suggested[8] for this purpose an equation which may be written most conveniently in the following form:

$$\Delta t = \frac{273.1 + t}{A}(2.8808 - \log_{10} B) \qquad (15)$$

where Δt is the correction in degrees which must be added to the boiling point, t, determined under the barometric pressure, B mm of mercury, in order to obtain the normal boiling point. A, like the Craft's constant, is a constant characteristic of the class of substances to which the liquid under examination belongs, and may be taken from a table of values of A for a variety of different types of substances. It may also be calculated from Trouton's constant, with which it is in fact identical, except for a constant factor independent of the nature of substance, as shown by the following relation:

$$A = 0.2186 \frac{L}{T_B} \qquad (16)$$

In fact, equation (15) is nothing more than our old friend the integral of the Clausius-Clapeyron equation, somewhat rearranged and with the ratio $\frac{L}{T_B}$ taken as a constant, in accordance with Trouton's rule. For small pressure differences, equation (15) reduces directly to the familiar form known as Craft's equation. It assumes further that log p is a linear function of $\frac{1}{T}$.

The constant c in Craft's equation

$$\Delta t = cT_B(760 - P) \qquad (17)$$

is related to the constant A, by the equation

$$c = \frac{5.72.10^{-4}}{A} \qquad (18)$$

The following table illustrates the difference in the correction, Δt, as calculated by equation (15) and by Craft's equation, respectively, for two barometric pressures.

TABLE V

$\frac{L}{T_B}$ assumed = 22 T_B, assumed = 500°	Boston $B = 770$	Santa Fé $B = 580$
Δ_t, from equation 15	−0.590	12.20
Δ_t from Craft's equation	−0.594	10.7

The value of B at which the difference between the equations amounts to a given fraction of a degree depends upon the value of T_B. Thus for $T_B = 500°$, or $t_B = 227°$, this difference reaches 0.1° at $B =$ about 710 mm.

The "air-solubility" effect of the atmosphere upon the boiling point of a liquid has apparently never been investigated. The normal boiling point of a *pure* liquid should in general be higher than the normal boiling point of the same liquid saturated with dry air. The difference, while small, should be capable of experimental determination with our present accurate methods of measuring boiling points. The effect, if appreciable, would cause the boiling point determined in the usual manner to fall off of the vapor pressure curve of the liquid as determined by the static method.

(5) Boiling Point Raisings

In the determination of the boiling-point elevation produced by non-volatile solutes it is essential for accurate work either to use a manostat or to make the method a differential one; that is, duplicate sets of apparatus, one containing the boiling solvent and the other the boiling solution, should be operated side-by-side and simultaneously. If this is not done the boiling point of the solvent will not be known for the conditions prevailing at the time the measurements are made with the solutions, due to local fluctuations in barometric pressure frequently too small to be registered by a mercury barometer but still large enough to produce errors in the boiling point measurements, which with the differential method can be made with a precision of 0.001° C.

The molal boiling-point raising for a given solvent is itself likewise a function of the barometric pressure and in recording in the literature measured values of this constant the barometric pressure should always be stated or, better, the measured value should be corrected to standard barometric pressure. The correction varies somewhat with the nature of the solvent, but it is approximately 0.3 per cent. per cm of mercury for all solvents.[9] Thus two determinations of the molal boiling point raising by identical methods of measurement, one made at Harvard and one at the University of Colorado, might differ by as much as 5 or 6 per cent. owing to differences in barometric pressure. Some of the apparent discrepancies in the "ebbullioscopic constants" reported in the literature may perhaps be traced to this cause.

(6) Specific Heats

Corresponding to the conditions under which the calorimetric measurements are carried out, we may distinguish the following types of specific heats:

[8] Personal communication.

[9] The exact expression for this correction is given on page 737, Volume 41, *Jour. Amer. Chem. Soc.*, (1919).

(1) C_v, the specific heat at constant volume. This quantity is seldom if ever directly measured in the case of liquids. When required, it is computed from one of the other types.

(2) C_p, the specific heat under constant external pressure. This quantity is also, strictly speaking, seldom if ever directly measured in the case of liquids. It is ordinarily identical, within the experimental error, with the quantities C_p or C_s and in any case can be obtained from them by applying the proper corrections.

(3) C_p, the quantity $\frac{dH}{dt}$ for unit mass of the liquid (or solid) in contact with a negligible (or allowed-for) mass of its saturated vapor and under its own vapor pressure at all temperatures. In the case of solids this quantity is also the so-called specific-heat-in-vacuo which is directly measured in calorimeters of the Nernst aneroid type. This quantity as directly measured is not, strictly speaking, a true specific heat, since it includes also a certain amount of latent heat, namely, the amount required to vaporize that amount of substance which is required to produce saturated vapor at the higher temperature. The amount of this latent heat is thus a function of the size of the container. The quantity C_p also includes the (usually negligible) change in internal energy corresponding to the change in pressure. When correction is made for these two effects the corrected C_p becomes C_p for $P = p$.

(4) C_s, the quantity $\frac{dH}{dt}$ when the liquid is heated in equilibrium with the atmosphere under constant barometric pressure but in a confined space. To obtain C_p from C_s it is necessary to correct for evaporation as in case (3) and also to correct for the heat absorbed in volatilizing the amount of dissolved $O_2 + N_2$ corresponding to the different solubilities of these gases at the initial and final temperatures respectively unless, as is usually the case under the conditions of the experiment, this volatilization is made negligible.

It is also necessary to subtract the partial specific heats, $\bar{C}_s$, of the dissolved $O_2 + N_2$ from the measured $\bar{C}_s$ of the saturated solution. Needless to say when working with liquids other than water contact with atmospheric moisture should be avoided in accurate work.

With the exception of the latent heat correction (which is significant under certain conditions), all the above corrections are in most if not all cases probably within the experimental errors of modern calorimetry, and therefore have only an academic interest at the present time.

(7) LATENT HEAT OF VAPORIZATION OF A LIQUID

The following discussion of the latent heat of vaporization will exemplify the effect of atmospheric conditions upon the measurement of latent heats of phase changes in general. We may distinguish the following three kinds of latent heats of vaporization, L:

(1) L_p, the latent heat under the vapor pressure p. This is the quantity ordinarily measured calorimetrically either by boiling the liquid in the calorimeter or by condensing into the calorimeter the saturated vapor of the boiling liquid.

(2) L_P, the latent heat of the pure liquid under constant external pressure P, the same at all temperatures. This quantity is never measured calorimetrically, although it appears in thermodynamic equations and is calculable therefrom.

(3) L_s, the latent heat of vaporization of the liquid plus its dissolved air under constant atmospheric pressure. This is the quantity measured calorimetrically by the method of A. W. Smith, in which the liquid contained in the calorimeter is vaporized by means of a current of dry air.

With the aid of the First Law of Thermodynamics we can readily deduce the following relations:

$$L_p - L_P = (P - p)V - \Delta E \qquad (19)$$

where ΔE is the decrease in internal energy which accompanies the isothermal compression of the liquid from p to P.

$$L_s - L_P = \bar{L}_O S_O + \bar{L}_N S_N \qquad (20)$$

where $\bar{L}_O$ and L_N are the partial latent heats of vaporization of the dissolved O_2 and N_2 (neglecting Ar), and S_O and S_N the corresponding solubilities of these gases.

Calculation for Water at 30°.—To illustrate the order of magnitude of the corrections in the case of water, we will apply the equations to the vaporization of water at 30°.

(a) The direct pressure effect.—By interpolation on the graph given by Bridgman,[10] we find

$$\Delta E = 0.00297P \text{ cal. mole}^{-1} \qquad (21)$$

and hence

$$\Delta E \text{ from } p \text{ to 1 atm.} = \frac{0.0297(760 - 31.8)}{760}$$

$$= 0.028 \text{ cal. mole}^{-1} \qquad (22)$$

$$(P - p)V = \frac{760 - 31.8}{760} \times 0.001004 \times 18 = 0.0181$$

$$\text{l. atm.} = 0.044 \text{ cal. mole}^{-1} \qquad (23)$$

and hence

$$L_p - L_P = 0.044 - 0.028 = 0.016 \text{ cal. mole}^{-1} \qquad (24)$$

[10] Bridgman, Proc. Amer. Acad., *48*, 348 (1912).

This difference is well within the accuracy with which L_p has been measured.

(b) The air-solubility effect.—From the solubilities of O_2 and N_2 in water at 16° and 30°, the Second Law enables us to compute $\bar{L}_o$ and $\bar{L}_N$, giving

$$L_o = 3360 \text{ cal. mole}^{-1} \quad (25)$$

$$L_N = 3040 \text{ cal. mole}^{-1} \quad (26)$$

and from the determinations of Winther at 30° we obtain

$$S_o = 4.23 \times 10^{-6} \text{ moles per mole} \quad (27)$$

$$S_N = 8.34 \times 10^{-6} \text{ moles per mole} \quad (28)$$

and hence

$$L_oS_o + L_NS_N = 0.040 \text{ cal.} \quad (29)$$

$$L_s - L_p = 0.040 \text{ cal. mole}^{-1} \quad (30)$$

and

$$L_s - L_p = 0.024 \text{ cal. mole}^{-1} \quad (31)$$

The difference between L_s and L_p is thus also well within the experimental accuracy with which either of these quantities has been measured up to the present.

(8) Density of Liquids

Owing to the slight compressibility of liquids it is customary to ignore barometric influences in making density determinations, and this is indeed justifiable except in determinations where the fifth or sixth decimal is significant. The following table illustrates the order of magnitude of the direct pressure effect for two liquids.

TABLE VI

Density at Room Temperatures

	at Boston $B = 770$	at Santa Fé $B = 580$	Per cent. Difference
Water	0.998230	0.998217	0.0013
Ether	0.713500	0.713464	0.005

The effect of dissolved air upon the density of a liquid can not be computed. It has, however, been determined in the case of water, and its maximum total effect is only 3 units in the sixth decimal place.

It may seem superfluous to point out that all density determinations reported by investigators should be based upon weights *in-vacuo* but it is unfortunately true that many such data recorded in the literature have apparently not been reduced to the *in-vacuo* basis, since information on this point is frequently entirely lacking in the paper.

(9) Other Physical Properties

Information is lacking concerning the magnitude of the effect of the atmosphere upon the measurement of most physical properties of solids and liquids, since it can usually be discovered only by direct investigation. The inference is that it is probably negligible in most instances. The following additional illustrations of the "direct pressure effect" may, however, be deduced from available information.

Viscosity of Ethyl Ether

at Boston $B = 770$	at Santa Fé $B = 580$	Per Cent. Difference
0.0023400	0.0023381	0.08

Solubility

m — Dinitrobenzene in ethyl acetate.		
34.432	34.435	0.01
$Ba(OH)_2.8H_2O$ in H_2O.		
8.3000	8.2984	0.02

Edward W. Washburn
National Research Council
Washington, D. C.

THE TOLL OF THE AUTOMOBILE

We hear and read a good deal of the enormous annual toll of human life due to the mania for speed so generally prevalent among automobile drivers. On this account our city streets and country highways are dangerous places for pedestrians as well as for other and more discreet motorists. Even the widely heralded "dirt roads" of Iowa are tainted with human blood. "As a killer of men, the automobile is more deadly than typhoid fever and runs a close second to influenza. . . . Up to August of this year (1924) 9,500 lives were sacrificed, chiefly in preventable accidents." Thus reads a recent account in one of our popular magazines.

Not only is the mortality among human beings high, but the death-dealing qualities of the motor car are making serious inroads on our native mammals, birds and other forms of animal life.

This matter was most forcefully brought to my attention during June and July, 1924, when my wife and I made the journey overland from Iowa City, Iowa, to the Iowa Lakeside Laboratory, on West Lake Okoboji, Iowa, a distance of 316 miles. Parts of two days were occupied in the going journey on June 13 and 14, while approximately the same time was required for the return trip on July 15 and 16.

Within a few minutes after we had started from Iowa City and a considerable number of dead animals, apparently casualties from passing motor cars, had been encountered in the road, it occurred to us

that an enumeration and actual count of those that we might yet come upon during the remainder of the tour would be of interest. Accordingly, we undertook to do this on both the going and return trip which, although not over the same routes in their entirety, were of exactly the same length.

In this count only freshly killed carcasses of vertebrate animals lying in or immediately at the side of the highway were taken into consideration, and only those forms of whose identity we were certain as we passed along were included. Since we seldom exceeded 25 miles per hour we had ample time to identify the more familiar things. Stops were made for a few of the less common and unusual finds.

Our route took us through typical Iowa farming communities, for the most part moderately thickly populated and supplied with the usual farm buildings. Prairie, marsh and woodland were also represented as were various types of soil and vegetation supported by them. All these conditions make for a diversity of animal life, and we found it well represented on the highways.

About 200 miles of the road were graveled; the remainder was just "plain dirt," most of which had been brought to grade. Of course the surfaced roads permit of greater speed, together with more comfort to the speeder and correspondingly greater danger to human and other lives.

In general, the greatest number of casualties were encountered on the good stretches of road. By way of illustrating this point it may be noted that on the return journey between the Laboratory and Marshalltown, Iowa, a distance of 211 miles, all well graveled, 105 dead animals representing 15 species were counted; of these, 39 were red-headed woodpeckers (*Melanerpes erythrocephalus*). Several other forms that could not be identified in passing were met with.

As will be seen from the appended table the mortality among red-headed woodpeckers is higher than that of any other form observed, and I believe that a combination of circumstances will account for this situation. In the first place, these birds have a propensity for feeding upon insects and waste grain in and along the roads; second, they remain as long as possible before the approaching car, in all probability not being keen discriminators of its speed; and third, they have a slow "get-away," that is, they can not quickly acquire a sufficient velocity to escape the oncoming car and so meet their death. However, I feel certain that a speed of from 35 to 40 miles an hour is necessary in order to catch these birds. Of course this is not true for some other forms such as turtles and snakes which depend upon terrestrial progression and are comparatively slow movers. In most cases all animals, if given a reasonable time to escape, will cause the hurried motorist little if any delay.

Further comment need not be made upon the various factors entering into the situation here discussed. It will be sufficient to point out that on a summer motor trip of 632 miles over Iowa roads, 29 species of our native and introduced vertebrate animals, representing a total of 225 individuals, were found dead as a result of being crushed by passing automobiles, and that this agency demands recognition as one of the important checks upon the natural increase of many forms of life. Assuming that these conditions prevail over the thousands of miles of improved highways in this state and throughout the United States the death toll of the motor car becomes still more appalling.

The details of our findings are herewith recorded in tabular form:

	June 13–14	July 15–16
REPTILES		
1. Snapping turtle (*Chelydra serpentina*)	—	3
2. Painted terrapin (*Chrysemys* sp.)	1	6
3. Blue racer (*Zamenis constrictor*)	1	—
4. Garter snake (*Eutaenia* sp.)	14	—
5. Bull snake (*Pituophis* sp.)	3	1
6. Other snakes (may include some of the above)	1	10
BIRDS		
7. Fowl (*Gallus domesticus*)	6	20
8. Mourning dove (*Zenaidura macroura carolinensis*)	2	1
9. Yellow-billed cuckoo (*Coccyzus a. americanus*)	—	1
10. Hairy woodpecker (*Dryobates v. villosus*)	—	1
11. Red-headed woodpecker (*Melanerpes erythrocephalus*)	10	43
12. Red-bellied woodpecker (*Centurus carolinus*)	2	—
13. Northern flicker (*Colaptes auratus luteus*)	5	14
14. Meadowlark (*Sturnella* sp.)	1	—
15. Bronzed grackle (*Quiscalus quiscala aeneus*)	4	1
16. English sparrow (*Passer domesticus*)	5	15
17. Shrike (Migrant?) (*Lanius ludovicianus (migrans?)*)	1	—
18. Catbird (*Dumetella carolinensis*)	—	1
19. Brown thrasher (*Toxostoma rufum*)	—	5
20. Robin (*Planesticus m. migratorius*)	1	3
MAMMALS		
21. Western fox squirrel (*Sciurus niger rufiventer*)	—	2
22. Thirteen-lined spermophile (*Citellus t. tridecemlineatus*)	13	5
23. Franklin's spermophile (*Citellus franklini*)	3	—
24. Woodchuck (*Marmota m. monax*)	—	1
25. Norway rat (*Rattus norvegicus*)	—	1
26. Cottontail rabbit (*Sylvilagus* sp.)	8	4
27. Skunk (*Mephitis putorius*)	1	—
28. Weasel (*Putorius longicaudus*)	2	—
29. Cat (*Felis domesticus*)	—	3
Total	84	141

DAYTON STONER

UNIVERSITY OF IOWA

INTERNATIONAL CONGRESS OF PLANT SCIENCES

AT representative meetings of American botanists (Botanical Society of America, American Phytopathological Society, Ecological Society of America) held in Cincinnati, December, 1923, a proposal suggesting the desirability of holding an international congress for all workers in the fields of the plant sciences (botany in its widest applications) was enthusiastically approved.

In making the proposal it was clearly recognized that in view of preparations made, and then necessarily abandoned, for a Fourth International Botanical Congress in London in 1915 (as authorized by the executive committee of the Brussels Congress, 1910), the British botanists enjoyed, if they wished to exercise it, a prior claim in respect to such arrangements. Further, there were endorsed by the three societies mentioned suggestions that if at the present time British botanists did not wish to undertake arrangements on British soil for such a congress, but would be willing or would prefer to have the initiative taken in the United States, then American botanists would gladly undertake to bring about an international gathering at a date as early as might seem practicable. Representing the three societies, there was appointed an organizing committee consisting of H. C. Cowles (Ecological Society), B. M. Duggar (Botanical Society) and H. H. Whetzel (Phytopathological Society). This committee was authorized to ascertain the wishes of British botanists, and if a favorable sentiment was manifest toward convening the congress in the United States, to proceed with the necessary arrangements.

Communicating with one of the presidents and with the secretary representing the proposed congress in London, of 1915, it seemed that the initiative might well be taken by American botanists, as indicated by excerpts from the letters received.

> I think I am able to state with some degree of confidence that British botanists, so far from wishing to maintain any prior claim to holding a congress in Britain at this time or in the immediate future, would welcome the idea of the first post-war meeting being in America. As a matter of fact a British Imperial Congress has been arranged this year in London, and it is in a measure substitutionary for the International Congress which was normally due in London in 1915. It was thought that even in 1924 the time was hardly yet propitious for the International Congress to meet in this country. I am sure we shall all appreciate the delicacy with which you touch on the question of our possible prior claim, and I personally welcome your proposal. (Extract from letter of Professor F. O. Bower, President.)

> On the other hand, we should, I am sure, do our best to render successful a congress initiated in America. . . . I took the opportunity of reading your letter to a small executive committee of the Imperial Congress. The members were much interested and, though unable to speak for British botanists as a whole, were quite in accord with the views I have expressed. (Extract from letter of Dr. A. B. Rendle, Secretary.)

Later there was transmitted by Mr. F. T. Brooks (secretary) a statement from the executive committee of the Imperial Botanical Conference (held in London July 7–16) advising that the conference had no objection to the proposal submitted.

The organizing committee has accordingly proceeded with plans for an international congress, and it has thus far formulated the following general regulations and tentative schedule:

1. An International Congress of Plant Sciences (Fourth International Botanical Congress) shall be held in Ithaca, New York, August 16–23, 1926.
2. Membership in the congress shall be unrestricted and conditional only upon subscribing to any regulations announced and upon the payment of such nominal fee as may be necessary for legitimate expenses in organizing and conducting the congress.
3. In the scope of the congress shall be included the different branches of botanical science together with what are known as its broader applications in the fields of bacteriology, agriculture and forestry—these various aspects to be suitably grouped in sections. To the end that this characterization may be effective and practically inclusive, the cooperation of all the special American societies that may be interested in the general arrangements shall be solicited and urged.
4. The work of the congress shall be primarily with problems of fundamental research and teaching, but adequate opportunity shall be accorded all sections for the discussion of regulatory recommendations of international significance.
5. Ample time shall be reserved in the preparation of the program for excursions of interest to the various sections.
6. Particulars of the meetings, discussions and excursions shall be published as early as practicable.

Through the courtesy of the Imperial Botanical Conference in London and of the Fourth International Conference of Pedology in Rome, public European announcement of the congress has been made. Furthermore, while on a visit to many centers of botanical work in Europe, during the past summer, Dr. J. R. Schramm acted as the official representative of the organizing committee to draw the attention of botanists to the congress, as far as his contacts would permit. Likewise, in the interest of the

congress Dr. H. H. Whetzel and Dr. B. M. Duggar attended the meeting of the British Association at Toronto. A special effort will be made to reach all workers in the plant sciences.

The cooperative interest of the division of biology of the National Research Council and of the American Association for the Advancement of Science has been assured. The organizing committee records with special gratification the courtesy of Cornell University in permitting the use of its facilities for the congress, thus assuring a convenient geographical location and a most favorable physical environment. President Farrand's letter is appended.

CORNELL UNIVERSITY

Office of the President.

Ithaca, N. Y., Sept. 23, 1924.

Professor H. H. Whetzel,
College of Agriculture.

Dear Professor Whetzel:

I have been very much interested in hearing of the plans for the International Congress of Plant Sciences to be held in the summer of 1926 and I need not say that the prospect of having that important meeting in Ithaca is a source of great satisfaction to Cornell University. That our resources will be put entirely at the disposal of the congress goes without saying and the members may be assured of a very warm welcome.

I know of nothing which reacts with more benefit to a university than assemblies of this kind and I venture to hope that visitors from a distance may find something of interest here to justify the choice of place of meeting.

Sincerely yours,

(Signed) LIVINGSTON FARRAND.

The date arranged for the congress has been selected after taking into consideration a variety of circumstances affecting both the place of meeting and the convenience of those attending from far and near.

Organizing Committee:

H. C. COWLES, *Secretary*
B. M. DUGGAR, *Chairman*
H. H. WHETZEL

SCIENTIFIC EVENTS

LOGARITHMETICA BRITANNICA

THE Cambridge University Press is issuing under the auspices of the Biometrical Laboratory, University College, London, "Logarithmetica Britannica," a table of logarithms to twenty decimal places by Alex. J. Thompson, of the General Registrar's Office, Somerset House, London. Part Nine, the first to be published, contains the numbers 90,000 to 100,000.' In the prefatory note Professor Karl Pearson writes:

This year is the tercentenary of the first great work of Henry Briggs, the friend and coadjutor of Napier of Merchistoun, and the computer of the first, and still perhaps the most valuable, table of common logarithms. Briggs's *Arithmetica Logarithmica* appeared in 1624, one year before the death of King James. The growth of British mathematics amid the bloody faction and political turmoil of the Stuarts—especially noteworthy in the case of the wizard Laird of Merchistoun—is one of the remarkable facts in the history of science. But this is not the occasion to enter into that matter or indeed into the life of Briggs himself. The purpose of this publication lies in the endeavor to celebrate the tercentenary of his great achievement in a worthy manner. We would, however, willingly have provided a portrait of Briggs could such have been discovered, but inquiries in Cambridge, Oxford, London, of Lord Napier and Ettrick, and of the Yorkshire family of which he was a member have been fruitless, and the reader must be content with a specimen page of the scarce tract of 1617 in which Briggs first drew the notice of the scientific world to the advantages of logarithms to the base 10.

When it came to my knowledge that the French proposed to issue a fourteen figure table and the Germans a fifteen figure table, it seemed to me that it was fitting that the land wherein logarithms were cradled should rise to the occasion and issue a standard table—*Logarithmetica Britannica*—to twenty figures.

In a certain sense the day of logarithmic tables to 4, 5, 6 or 7 figures is past. The users of such tables are either ignorant of the existence of slide-rules and mechanical calculators, or else unfortunately can not afford them. Where much computing has to be done logarithms to a few figures are rarely if ever used. What are used and are often badly needed are logarithmic tables to 10, 15 or 20 figures. They are wanted for work where the more or less customary machines with 9×10 showing 18 and the more unusual and costly machines with 12×12 showing 20 figures on the slide fail to give results of adequate accuracy without great expenditure of labor. In statistical and computating laboratories—especially in cases where new tables have to be prepared for publication—the original Briggs or original Vega are in greater demand than any more contracted logarithmic tables. Yet their high cost, their rarity and uncorrected errors render, as the French and the Germans have recognized, new tables desirable.

THE DEEP SEA OCEANOGRAPHIC EXPEDITION OF THE NEW YORK ZOOLOGICAL SOCIETY[1]

PLANS for the Ninth Expedition of the Department of Tropical Research are well advanced. The *Arcturus* has been officially turned over to William Beebe, director of the forthcoming trip, and the plans for the building of the laboratory, extra staterooms, photographic room, etc., are complete.

The expedition will start early in January, and the first stop will be in the Sargasso Sea. The eastern

[1] From the Bulletin of the New York Zoological Society.

portion of this area will be explored and a month's stay made, at the point of greatest concentration of seaweed, by means of a large buoy anchored in about two miles of water.

The depths beneath this zone will be searched by all modern methods of dredge, trawl, nets, traps and hooks. In this way a more thorough knowledge will be gained of a single limited area in mid-ocean than has heretofore been achieved. The daily and weekly changes in temperatures, salinity and density of the water, and in animal life will be studied and recorded. In effect the ship will function as an island.

The *Arcturus* will have a movable bow-sprit or railed platform which can be lowered to within a few feet of the water, and from which any fish or other creatures floating in the path of the vessel can be harpooned or netted. There will be a runway with a hand-rail around the outside of the hull, which will give access to any part of the length of the ship's side. Large searchlights, crow's nests near the top of the masts and marine glasses will be in constant use to discover any interesting creatures within vision. There will be diving apparatus for work and study at shallow depths on submerged platforms in mid-ocean; numerous aquariums, tanks and wells for live fish; a dark room is to be built for the study of luminescence in deep-sea fishes, and complete equipment will be brought into play to capture forms of deep sea life of which comparatively little is known.

Most of the luminous fishes live at great depths; some of these creatures, however, that do not inhabit the actual abysses are known to rise nearer the surface at night, so nocturnal activities aboard the *Arcturus* will probably be almost equal to those of daylight hours. Dredging, trawling and the use of baited traps after dark may be the means of securing hitherto unknown forms of life.

One of the objects of particular interest will be the attempt to secure specimens of the giant squid, which so far is only known through the remains found in the stomachs of cetaceans.

A powerful wireless set will be installed on the ship and weekly reports, describing the progress of the expedition, will be sent out. Complete records will be kept by means of motion pictures, paintings and photographs, as well as by written descriptions and accounts. Casts and models of the more delicate and perishable animals will be made, and every effort is to be directed toward obtaining information as to the habits of various fishes.

The extent of the Sargasso Sea varies in accordance with wind and current, so that some cruising about will be necessary in order to determine the most favorable spot for locating the floating island. Between the extremes of giant cetaceans and microscopic plankton, there will be enough material for study to occupy every moment of the six months which it is proposed to spend on this deep-sea expedition.

PLANS OF THE ENGINEERING FOUNDATION

THE Engineering Foundation, New York, has appointed 190 leading engineers, representing industry, education and public service in twenty-seven cities throughout the country, to act as local representatives. These engineers will work with the Foundation Board in carrying out a nation-wide plan "for the furtherance of research in science and engineering or for the advancement in any other manner of the profession of engineering and the good of mankind."

The foundation's work will be carried on with $500,000 provided by Ambrose Swasey, of Cleveland, augmented by a recent gift of $50,000 from the estate of Henry R. Towne. The immediate direction of the foundation's affairs will be in the hands of a group of engineers in New York and other cities.

At present the foundation is cooperating with the National Research Council and the Research Committees of the various engineering societies in investigations of engineering problems.

With research committees of the founder societies of civil, mining and metallurgical, mechanical and electrical engineers, the foundation is cooperating in investigations of concrete and reinforced concrete arches, steel columns for buildings and bridges, mining methods, rock drill steels, properties of steam-bearing metals, lubrication and strength of gears.

Besides the foundation's appropriations to aid research, totaling $15,000, contributions from industries and other sources aggregate more than $100,000. Personnel research in industry, education and government will be furthered in 1925 through the personnel research federation.

Representatives announced are affiliated with numerous national organizations in addition to engineering societies, the list including the American Chemical Society, the American Association for the Advancement of Science, the Iron and Steel Institute, Society for Promotion of Engineering Education, American Society for Steel Testing and the American Meteorological Society.

PUBLIC LECTURES AT THE UNIVERSITY OF MINNESOTA

THE zoological museum of the University of Minnesota has announced the program for its fifth annual course of Sunday afternoon lectures. These lectures are being given at 3:30 P. M. in the animal biology building as follows:

January 4. *The winter bird life of Minnesota:* THOS. S. ROBERTS, director of the zoological museum, University

of Minnesota. Lantern slides, specimens and motion pictures.

January 11. *Pictures of Minnesota before the days of photography:* EDWARD C. GALE. Lantern slides of historical interest. One reel of motion pictures.

January 18. *Life and work of Charles Darwin:* CHARLES P. SIGERFOOS, professor of zoology, University of Minnesota. Lecture illustrated by lantern slides and followed by motion pictures.

January 25. *Spinners and weavers of the insect world:* WILLIAM A. RILEY, professor of entomology and economic zoology and chief of division of entomology and economic zoology, College of Agriculture, University of Minnesota.

February 1. *In Hawaiian waters:* ROYAL N. CHAPMAN, associate professor of animal biology, University of Minnesota. Illustrated by a series of colored slides and motion pictures.

February 8. *Among Hawaiian plants:* J. ARTHUR HARRIS, professor of botany and head of the department of botany, University of Minnesota. Illustrated with a series of colored slides and motion pictures.

February 15. *The forest as a plant community:* RAPHAEL ZON, chief of Lake States Forest Experiment Station, University of Minnesota. Illustrated by a series of specially prepared slides and followed by motion pictures.

February 22. *Some spineless denizens of the sea:* DWIGHT E. MINNICH, assistant professor of animal biology, University of Minnesota. Illustrated by four reels of motion pictures recently acquired by the department of animal biology.

March 1. *The river Jordan; adventures of a city man in the country:* WILLIAM C. EDGAR, former editor of *The Bellman* and *The Northwestern Miller*. Illustrated by lantern slides and followed by motion pictures.

March 8. *Birds of other lands in motion pictures.* Films showing the bird life of the American Tropics and foreign countries secured for this occasion.

March 15. *Men of the Old Stone Age:* CHARLES A. ERDMAN, associate professor of anatomy, University of Minnesota. Illustrated by lantern slides and followed by motion pictures.

March 22. *Wild flowers; where they grow and why:* N. L. HUFF, assistant professor of botany, University of Minnesota. Illustrated by lantern slides and motion pictures.

March 29. *Bird banding; history, object, methods and results:* THOS. S. ROBERTS, director of the Zoological Museum, University of Minnesota. Illustrated by lantern slides and motion pictures.

SCIENTIFIC NOTES AND NEWS

THE Silliman Lectures at Yale University are being given by Dr. Thomas Hunt Morgan, professor of experimental zoology at Columbia University, on the afternoons of January 12, 16, 19, 23, 26 and 30, at 4:30. The subject of the lectures is "The theory of the gene."

DR. SIMON FLEXNER, director of the Rockefeller Institute for Medical Research, will leave early in January for an extended trip to the Near East and Europe. He will be accompanied by his wife and joined later by his two sons. He returns to New York in September, 1925.

KNUD RASMUSSEN, the Danish explorer, has been awarded the Charles P. Daly Gold Medal of the American Geographical Society for 1924, for his explorations in Greenland and northern North America.

PROFESSOR C. VERNON BOYS has been awarded the second Duddell Memorial Medal by the Council of the Physical Society of London. According to the terms of the Duddell Memorial Trust, the award is "for the advancement of knowledge by the invention or design of scientific instruments or by the discovery of materials used in their construction."

PROFESSOR A. W. BICKERTON, of London, has been elected an honorary member of the New Zealand Astronomical Society in recognition of his work on cosmic evolution.

SIR JOSEPH THOMSON and Dr. W. C. Unwin have been elected honorary members of the Institution of Civil Engineers.

THE council of the Röntgen Society, England, has decided to present the Röntgen Award for the session 1923–1924 to L. H. Clark, of the department of physics, of Middlesex Hospital, for his papers (1) "A clinical x-ray balance radiometer," and (2) "On the measurement of x-ray intensity."

DR. E. F. ARMSTRONG, past president of the Society of Chemical Industry, has been elected president of the British Association of Chemists, succeeding Dr. Herbert Levinstein.

OSMOND CATTLIN, borough engineer of Lambeth, has been elected president of the Institution of Sanitary Engineers, England. He delivered his presidential address on January 12.

DR. ALEXANDER RUSSELL has been elected president of the Junior Institution of Engineers, England, for the session 1924–25. His inaugural address was delivered at the Royal Society of Arts on January 7.

IT is stated in *Nature* that at the opening of the hundred and fifty-fourth session of the Royal Physical Society of Edinburgh, the following officers were elected: *President,* Dr. James Ritchie; *vice-presidents,* Dr. Marion Newbigin and Professor J. Arthur Thomson; *secretary,* Dr. H. M. Vickers; *assistant secretary,* Professor J. Russell Greig; *librarian,* Mr. J. Kirke Nash, and *councillors,* Professor D'Arcy W. Thompson, Principal O. Charnock Bradley, Professor J. H. Ashworth, Professor J. Graham Kerr, Dr. J. R. Henderson and Mr. Hugh Miller.

H. L. HORNING, of Waukesha, Wis., has been elected president of the Society of Automotive Engineers to succeed H. M. Crane, of New York, at the annual dinner of the society in New York.

DR. GEORGE GRANT MACCURDY, of Yale University, was reelected director of the American School of Prehistoric Research in Europe at the annual meeting of the managing committee of the school held in Washington, D. C., on January 3.

DR. GEORGE F. WHITE, professor of organic and biological chemistry at Clark University, has resigned to take a position with Bauer and Black, Chicago, manufacturers of surgical supplies.

BRADFORD NOYES, JR., has accepted a position as physicist in the technical department, research division, of the Taylor Instrument Companies, Rochester, New York.

M. J. KIRWIN has resigned as superintendent of the United States Bureau of Mines Station, Bartlesville, Okla., to become production engineer for the Indian Territory Illuminating Oil Co.

DR. IRVINE MCQUARRIE has resigned his position in the department of pediatrics, Yale University, to become chief of the newly organized pediatric service at the Henry Ford Hospital, Detroit.

M. DOELLO-JURADO, professor at the University of Buenos Aires, was installed director of the National Museum of Natural History at Buenos Aires, on January 1, at the time of the celebration of the centenary of the museum.

DR. F. P. STOWELL, of the University of Liverpool, has been elected as the first aquarium research fellow of the Zoological Society of London. The fellowship has been established for the investigation of the conditions affecting aquatic life in fresh and salt water aquaria. In conjunction with the London School of Hygiene and Tropical Medicine, the Zoological Society has appointed Dr. H. H. Scott assistant-director in the department of helminthology in the tropical division of the school, as Milner research fellow in comparative pathology.

PROFESSOR A. FINDLAY, of the University of Aberdeen, has arrived in the United States, where he has come to act as substitute professor of chemistry at Leland Stanford University for the next nine months.

SIX European bacteriologists have been invited to the Rockefeller Institute for a three-months' study of the results of bacteriological experiments in epidemic influenza as follows: Dr. Ronald G. Canti, St. Bartholomew's Hospital, London; Dr. Louis Boez, Institute of Hygiene and Bacteriology, Strasbourg; Dr. Leon Muller, University of Liège, Belgium; Dr. Walter Levinthal, Robert Koch Institute, Berlin; Dr. Dino Nai, Milan, and Dr. Svend Ahrend Larsen, Statens Serum Institute, Copenhagen.

IT is reported that Professor Albert Einstein will leave for Buenos Aires on March 5, to deliver a series of lectures on the theory of relativity. He is making the trip upon the invitation of Argentine scientific institutions and societies.

D. A. MACINNES, of the department of chemistry, of the Massachusetts Institute of Technology, is in Europe visiting chemical laboratories in Zurich, Copenhagen and Cambridge.

DR. ALEXIS CARREL, of the Rockefeller Institute for Medical Research, sailed for Havre on December 10.

PROFESSOR EDWARD KASNER, professor of mathematics at Columbia University, spoke on "The mathematics of the Einstein theory," at the dinner of the chairmen of the departments of mathematics of the New York City high schools, Hotel Woodstock, on December 20.

DR. F. G. COTTRELL, director of the Fixed Nitrogen Research Laboratory, United States Department of Agriculture, gave a lecture at the Franklin Institute, Philadelphia, January 8, on "The future of nitrogen fixation."

DR. WILLIAM F. DURAND, recently elected president of the American Society of Mechanical Engineers, was the principal speaker at the meeting of the New York section of the American Institute of Mining and Metallurgical Engineers, held at the Harvard Club, on January 13.

ARTHUR D. LITTLE gave the Cyrus Fogg Brackett lecture at Princeton University on December 10. His subject was "The application of chemical research in industrial development."

DR. EDGAR T. WHERRY, of Washington, D. C., formerly professor at Lehigh University, spoke before the members of the Lehigh Valley Section of the American Chemical Society, December 12, on "Soil activity and its influence on plant growth."

HONORING Dr. Thomas C. Mendenhall, former chairman of the Board of Trustees, Ohio State University, whose death occurred last March, students at Salem High School have placed a bronze tablet, inscribed to his memory, in the entrance hall of the school. Dr. Mendenhall taught his first classes in the Salem schools.

THE Baskerville Chemical Society, of the College of the City of New York, has presented to the college a portrait of the late Professor Charles Baskerville, former head of the department of chemistry. The portrait, hung in the chemistry lecture room, was accepted in behalf of the department by Professor H. R. Moody, Professor Baskerville's successor.

DR. JOHN MARSHALL, emeritus professor of chemistry and toxicology in the University of Pennsylvania, died on January 5, aged sixty-nine years.

DR. GEORGE A. BATES, professor of histology at Tufts College, has died, aged seventy-seven years.

DR. ERNEST JEROME WINTER, consulting chemical engineer of New York City and an authority on the subject of distillation, died on November 23, aged forty-five years.

DURING the past week two French radiologists have died from the effects of injuries received in the pioneer days of X-ray and radium experimentation. Professor Bergonie, of Bordeaux, died on January 2, and Dr. M. Demenitroux, of Paris, died on January 3.

DR. ERNEST HEDINGER, professor of pathology at Zurich University, has died at the age of fifty-two years.

DR. FELIX TANNHAUSER, extra-ordinary professor of mineralogy and geology at the Technische Hochschule and the University of Berlin, died on December 2.

DR. CARLO DE STEFANI, professor of geology and physical geography in the Royal University of Florence, died on December 12.

IN addition to the election of Professor James F. Norris, professor of chemistry at the Massachusetts Institute of Technology, to be president of the American Chemical Society for 1925, other officers chosen are as follows: Directors: Professor E. C. Franklin, of Leland Stanford University, and Dr. W. D. Bigelow, director of the research laboratories of the National Canners Association, Washington, D. C.; Councillors-at-large: Professor T. B. Johnson, Yale University; Dr. A. M. Comey, Cambridge, Mass.; Professor W. Lee Lewis, Northwestern University, and Edward Mallinckrodt, Jr., manufacturer of St. Louis, Mo.

O. W. STOREY, chemical engineer with the C. F. Burgess Laboratories of Madison, was the speaker of the evening at the 137th regular meeting of the Wisconsin Section of the American Chemical Society. The title of his address was "The corrosion of iron and steel: Theory versus practice." At this meeting, which was the annual meeting of the section, the following officers were elected to serve for the year 1925: A. W. Schorger, of the Burgess Laboratories, *chairman;* L. F. Hawley, of the U. S. Forest Products Laboratory, *vice-chairman,* and H. N. Calderwood, *secretary-treasurer.* Victor Lenher and J. H. Walton, *councillors,* and H. A. Schuette, *editor,* all of the University of Wisconsin.

ALCOHOL in all its phases was the subject of a symposium conducted at the intersectional meeting of the American Chemical Society on January 10, at Boston University. Among the speakers were Kenneth M. Ware, of the Massachusetts Department of Public Health; Dr. Francis G. Benedict, director of the nutrition laboratory, Carnegie Institute; Dr. Reid Hunt, of the Harvard Medical School, and Dr. George Burgess Magrath, instructor in pathology at the Harvard Medical School.

THE Chicago Section of the Association of Iron and Steel Electrical Engineers will hold a joint meeting with the Chicago Section of the American Institute of Electrical Engineers and the Electrical Section of the Western Society of Engineers at the Atlantic Hotel, Chicago, on January 26.

THE Chicago Section of The American Society of Mechanical Engineers held their second Annual Power Meeting in the LaSalle Hotel, Chicago, on January 14 and 15. The first day was devoted to technical sessions for the presentation of papers. On the second day power plants were visited.

THE United States Geodetic Survey and the Carnegie Institution of Washington will cooperate with Cornell University in occupying a station at Ithaca for magnetic and atmospheric electric observations at the time of the eclipse on January 24. Professor Ernest Merritt, of Cornell, is interesting himself in the proposed cooperation. With observations on the eastern end of Long Island by the Carnegie Institution of Washington, and at Hamilton and Toronto by the Canadian Government, the three stations will lie at such intervals along the path of the eclipse that valuable indications may be obtained in regard to the time of occurrence of any phenomena that may be observed.

WE learn from *The Geographical Journal* that Lauge Koch is planning a new expedition for research in the Arctic. Its objects will be mainly geographical and cartographical, and the field of work will be Grant Land and other parts of Arctic Canada, where the explorer proposes to investigate and map the mountain range which he regards as the continuation of those explored in Northern Greenland, these being in turn, geologically, a section of a great arc running thither from Wales through Scotland, the Shetland Isles and Spitsbergen. Mr. Koch expects that the working up the results of his recent expedition will occupy a considerable time, so that his plans for the new expedition are still in the preliminary stage only.

A TEN-YEAR program, under which $40,000,000 would be appropriated for purchase of forest land and for forest conservation under the Clarke-McNary act and other conservation measures, would be authorized under a bill recently introduced in the Sen-

ate and in the House. Purchase of about 8,000,000 acres would be made, principally in the eastern and Great Lakes watershed territories. The American Forestry Association, sponsoring the measure, suggested that the funds be expended in speeding up forest purchases in the White Mountains, the Appalachians and the Pine regions of the Southern and lake States. About 3,000,000 additional acres are necessary for proper conservation and protection of timber in the White and Appalachian Mountains. Association officials declared that under careful management the proposed federal timber areas, in addition to producing lumber and pulpwood and protecting stream flow, would furnish recreation spaces for three fourths of the nation's population.

AFTER having heard representatives of the Geological Survey, the Bureau of Soils and others concerned, the Committee on Mines and Mining of the House of Representatives is expected to report favorably the Shepperd bill, which authorizes the expenditure of $500,000 for prospecting and research looking to the development of domestic potash resources. The Shepperd bill has already been passed by the Senate. While it is probable that the larger proportion of the appropriation would be expended in prospecting operations with core drills in the southwest, where thin beds of potash have already been found, there also would be extensive work on the recovery of potash from blast-furnace, cement mill, sugar mill and distillery operations. Among those testifying were Dr. George Otis Smith, director of the Geological Survey; George R. Mansfield, potash specialist of the survey, and Dr. J. W. Turrentine, of the Bureau of Soils.

WE learn from *Nature* that the National Research Council of Japan has initiated an active program of scientific publication, in several series of "Japanese Journals" under the separate headings of chemistry, physics, geology and geography, botany, zoology, medical sciences, engineering, mathematics and astronomy and geophysics. The first two of these journals each appear in ten numbers annually, the third appears quarterly, while the remainder are occasional publications. The second part of Volume II of the *Japanese Journal of Astronomy and Geophysics* has just been issued, and contains six memoirs, occupying about sixty octavo pages. The papers cover a wide range of interests—precise levelling, theory of monsoon rainfalls, gravitational fields, thermal expansion of rocks and tidal undulations—and in some cases originate from research institutes, independent or connected with universities or colleges. They indicate a highly satisfactory state of activity and interest in geophysical research in Japan. All the papers are in English.

THE compilation of the proposed list of the insects of New York State is now to be completed. Dr. M. D. Leonard, who was appointed editor-in-chief while acting state entomologist of New York, returned to the department of entomology at Cornell University, in December, to again take charge of the project. His entire time will be devoted to the completion of this list and the New York State College of Agriculture has definitely promised publication, provided the manuscript is ready by June 1, 1925. It is estimated that over 16,000 species will be listed as definitely occurring in New York, together with as complete distribution data within the state as is known for each species. Several orders are already practically completed. Over one hundred of the leading specialists are actively cooperating. The editor of the list will appreciate definite New York State records in all groups and will see that full credit is given to every cooperator.

To allow greater time for the assimilation and consideration of data bearing on scientific advances in fighting cancer, the commission of award of the prize for cancer research, founded by Dr. Sofie A. Nordhoff-Jung, a resident of Washington, has decided to distribute the prize every two years, rather than every year, and to make the biennial award of $1,000 in lieu of the $500 annual prize. In December, 1923, the award was given to Dr. Johannes Fibiger, professor of pathological anatomy at the University of Copenhagen.

THE Benning National Forest, near Columbus, Ga., has been formally created by proclamation of the President. The forest is located within the area embraced by the Fort Benning Military Reservation, the forest boundaries including about 80 per cent. of the military reservation, or 78,500 acres. An excellent stand of Southern pine timber is on the Benning area and the Forest Service expects to harvest forest products both for military use and for sale. One fourth of the receipts from the Benning National Forest will be turned back to the counties in which the forest is situated for school and road funds.

AN expedition into the Kalahari Desert has been organized by the South African government to discover the breeding places of the locusts that come forth in the summer and swarm over the farms of South Africa, destroying everything in their wake. It is hoped eventually to send a small army into this desert, armed with sprayers and all the paraphernalia for killing the pest.

THE Missouri Botanical Garden has acquired recently the private herbarium and botanical library of the late Rev. John Davis, of Hannibal, Missouri. The collection of plants consists of approximately 20,000 specimens representing principally the flora of Missouri, Illinois and South Carolina.

UNIVERSITY AND EDUCATIONAL NOTES

IT is reported that three new Italian universities located in the cities of Milan, Florence and Bari were inaugurated with the new year.

THE Michigan College of Mines is arranging to add courses to its curriculum in the lines of electrometallurgy and metallography, and will develop comprehensive divisions in these branches. The new courses will be started during the coming year, as soon as the metallurgical building now being erected is completed and equipment installed.

TWO new buildings to be started during the coming year will mark the beginning of a 50-year building program for Wooster College, Ohio, which will include construction of several additional buildings and the abandonment of two now in use.

AT Princeton University, Dr. Luther Eisenhart, professor of mathematics, has been elected dean of the faculty in the place of Professor W. F. Magie, who has resigned.

DR. L. W. DURRELL, who was formerly the assistant chief in plant pathology at Iowa State Agricultural Experiment Station, has recently been appointed head of the department of botany and plant pathology at the Colorado State Agricultural College.

LANCASTER D. BURLING, formerly of the Smithsonian Institution and of the Canadian Geological Survey, is teaching geology in Vassar College.

DR. CHINGSON Y. LING, who is now at the University of Pennsylvania Graduate School of Medicine, Philadelphia, will return to China this winter to become the head of a department of bacteriology and pathology in the medical college at Shanghai, China.

DR. J. REILLY, assistant state chemist to the Irish Free State, has been appointed professor of chemistry in University College, Cork (National University of Ireland), in succession to Professor A. E. Dixon.

PROFESSOR GERLACH, of Frankfort, has been invited to occupy the chair of physics at the University of Tübingen in succession to Professor F. Paschen, who was recently appointed president of the Physikalisch Technische Reichsanstalt in Berlin.

DISCUSSION AND CORRESPONDENCE

THE REACTION OF THE COTTON PLANT

TWO papers have recently appeared in SCIENCE under the title "Alkaline reaction of the cotton plant."[1]

While it is clear from the text of these two notes that they refer primarily to dew collected from the leaves of the plant, as studied by Smith,[2] and to volatile constituents which might be dissolved in the dew, as studied by Power and Chesnut (*loc. cit.*), the titles of the two notes might be misleading in suggesting that the tissue fluids themselves are alkaline in reaction. Furthermore, it seems difficult to understand how the reaction of surface moisture can be considered entirely without reference to the hydrogen-ion concentration of the tissue fluids themselves.

During the past four years we have made many hundreds of determinations of the hydrogen-ion concentration of the tissue fluids expressed[3] from mature leaves of Egyptian and Upland varieties of cotton as grown under irrigation in experiments conducted for the Office of Alkali and Drought Resistant Plant Investigations of the Bureau of Plant Industry at the Cooperative Testing Station in the Gila River Valley at Sacaton, Arizona. These have, practically without exception, indicated a hydrogen-ion concentration well on the acid side of neutrality. The average values[4] for the series of Pima Egyptian cotton grown in 1921 range from pH 5.25 to 5.41, whereas for the series of Upland cotton grown under similar conditions they range from pH 5.35 to 5.46. In general the hydrogen-ion concentration of the tissue fluids of the Egyptian type of cotton is higher than that of the Upland type. The hydrogen-ion concentration of the tissue fluids of the F_1 hybrid is intermediate between that of the Egyptian and Upland types, being on the average lower than the Egyptian and higher than the Upland parent.

The fact that the tissue fluids of the cotton plant are acid rather than alkaline is, therefore, in agreement with the great majority of wild and cultivated plants as studied by Atkins, Haas, Hoagland, Truog and others, and as found in large series of unpublished observations by ourselves. In our experience only the tissue fluids of *Mentzelia* of the Loasaceae and all representatives of the Cucurbitaceae so far studied have a neutral or significantly alkaline reaction.

J. ARTHUR HARRIS
W. F. HOFFMAN
ARNOLD H. JOHNSON
UNIVERSITY OF MINNESOTA

[1] Mills, J. E., SCIENCE, n. s., 60: 268, 1924; Power, F. B., and Chesnut, V. K., SCIENCE, n. s., 60: 405, 1924.

[2] Smith, C. M., *Jour. Agr. Res.*, 26: 191–194.

[3] Mills (*loc. cit.*) noted no evidence of an alkaline reaction to phenolphthalein when young stems and leaves of cotton were crushed in water.

[4] Harris, J. Arthur, Lawrence, Z. W., Hoffman, W. F., Lawrence, J. V., and Valentine, A. T., *Jour. Agr. Res.*, 27: 295–298, 305–308, 1924. These results have been confirmed by large series of determinations as yet unpublished.

ABSTRACTS AND THE ZOOLOGICAL RECORD

British zoologists take a deep interest in the large scheme for the preparation and publication of biological abstracts explained to many of us this summer by President McClung and Dr. Schramm, and further discussed at the Toronto meeting of the British Association. I do not doubt but that, so far as it may be within our powers, we shall do our best to assist it. But we are in anxiety on several points.

The annual output of zoological papers is very large and abstracts of them, if sufficiently detailed to be of real use, will occupy a space that may surprise the managers of the scheme. Many papers, moreover, relate to several subjects, such as systematic zoology, ethnology, embryology, anatomy and physiology, and will require either separate abstracts or a complex system of indexing. If, from necessity or from policy, a selection is to be made, omissions which seem of no importance now may be much regretted in future. As an example, I may recall the well-known oblivion which buried Mendel's work for many years because its importance was unrecognized at the time. We are also in special anxiety as to the practical possibility of abstracting purely systematic work.

In any case it will take some years before the new scheme can be in full working order, its range defined, its personnel selected and trained, and its qualities judged. In our opinion it would be disaster were *The Zoological Record* to be crushed out of existence until it could be seen how far the international abstracts made it unnecessary, suggested a new form for it (such, for example, as limitation to systematic zoology and geographical distribution), or came into a cooperative scheme with it.

Our fears have a present and a historical justification. Already some institutions have refused to support *The Zoological Record* on the ground that abstracts will suit them better. When "The International Catalogue of Scientific Literature" came into existence, its mere appearance nearly halved our sales, although in the opinion of many the zoology volume of the catalogue was inferior to the *Record*. Fortunately I was able, after much persuasion of reluctant colleagues, to save the *Record* by arranging a provisional amalgamation between it and the zoology volume of the catalogue on terms which were to the advantage of both enterprises and left us with the option to continue the *Record* if the international catalogue broke down.

The international catalogue did in fact break down, whether the causes were, as I think, the inertia of its system, or, as some think, the circumstances of the war. The Zoological Society of London, desiring to preserve the continuity of an annual issue which has proved of increasing use to zoological science since 1864, resumed the whole burden, and has produced the volumes for the years 1915 to 1921 inclusive at an actual net loss of over £3,000 for six of these and an estimated loss of over £600 for the seventh (1921).

But the Zoological Society of London is a private corporation, receiving no aid from any public funds. My colleagues on its council felt that they had no right to shoulder the burden of zoological bibliography alone to the detriment of other scientific calls on the funds of the society. We made it known, therefore, that although we were prepared to regard an annual loss of £500 as our contribution, we could not continue to publish *The Zoological Record* unless we were assured of the necessary additional support from other zoological institutions and zoologists. Further, we made it known that if we received donations in excess of the loss beyond our own contribution of £500 for the year 1922, we should carry forward that balance to the credit of the succeeding volume in addition to another donation of £500 from our own funds.

We actually received £684 in donations in addition to our £500, and the cost of printing was less than we had anticipated so that we have been able to carry forward approximately £275 towards the volume for 1923. This volume, which is now going through the press and will be issued complete early in 1925, will almost certainly be larger than that for 1922, but with our own donation, the balance carried forward and the efforts of other British societies we shall probably be able to make both ends meet.

I desire to state, however, that the United States of America has so far contributed only a total of approximately £107 of which the large proportion of £35, has come from two individuals—my friends Dr. T. Barbour and Dr. Henshaw of Cambridge, Mass.[1] Is it too much to ask that zoological institutions and zoologists of America should together contribute say £250 a year for the five volumes 1924–1928 inclusive—just one half what this single society is prepared to find? It is not much to ask. If this can be done, I have little doubt but that other British institutions will be able to guarantee the remainder of the deficit and so secure the continuity of a valuable aid to zoological science during the period in which the system of abstracts is being established and give time to see whether the new system will make the *Record* unnecessary, or whether it is possible to arrange a scheme of efficient cooperation and economical division of labor.

London, England P. Chalmers Mitchell

[1] Dr. Barbour has increased his subscription to £50 in the hope that this will lead to increased support from America.

PURPLE BACTERIA AS SYMBIONTS OF A LICHEN

THUS far lichens have been considered as being fungi with which are associated certain algae, and it is supposed that at least in certain species both may live to common advantage.

It seems, however, another symbiosis is possible, which I have observed on a lichen thus far known as *Chiodecton sanguineum* (Sw.) Waino. It is a very conspicuous and attractive species, which I have found abundantly in Florida and in some parts of the island of Cuba. One encounters it especially in the damp hummocks growing against stems of *Quercus virginiana, Magnolia grandiflora* and of some other trees.

It is a crustlike lichen which is nearly round or irregular in shape and may develop a diameter of from half a centimeter to about two decimeters. Its characteristic is its center of a grayish to bluish gray color surrounded by a deep red margin, which is as far as I am aware never absent. On the grayish parts of the upper side of the lichen some red-colored blotches may appear in streaks or in small spots. Whereas the upper surface is thus almost gray, the lower one is deep red.

When this lichen is observed under high power of the microscope it is at once evident that the red color is caused by small organisms, which surround the hyphae of the fungus.

It is generally accepted that the algal symbiont of *Chiodecton* is a species of *Trentepohlia*. This is, however, not the case with this species of lichen. The red organisms have not a single characteristic in common with the *Trentepohlia*. In fact, they are not green algae nor blue-green algae; but these are purple bacteria.

They are oval and vary from 1.5 to 2 microns in length; they possess no flagella but show a vivid Brownian movement, as the same is present when they are dead. The bacterial cells contain the well-known bacteriopurpurin.

Cultures and subcultures and various other investigations with these bacteria have been made by the writer, which have proved that they belong to the genus *Rhodobacterium*. The name of the lichen has consequently been changed into *Rhodobacteriophora sanguinea*, and this new species of purple bacteria has been given the name of *Rhodobacterium lichenophora*.

An extensive account of my research of this interesting lichen will appear soon in one of the botanical periodicals.

J. C. TH. UPHOF

ORLANDO, FLORIDA

LIBRARIANS AND SCIENTIFIC RESEARCH

THE following statement was accidentally gleaned from the "Report of the Librarian of Congress," Washington, Government Printing Press, 1923, Page 205. (On reclassification of Library Service).

9. To hold the staff permanent, a maximum of less than $6,000 is unsafe, and in a library, permanence in the staff positions is essential. A scientist engaged in intensive research can readily pass over his work to his successor, who will take it up where he leaves off. The specialist leaving a library takes with him an accumulated knowledge of the particular collections and the apparatus, and an acquired experience in interpretation, which can not be replaced.

The librarian of Congress would be a better librarian if he understood better the conditions of scientific research.

B.

SCIENTIFIC BOOKS

The Fauna of British India, including Ceylon and Burma. Oligochaeta. By J. STEPHENSON. London: Taylor and Francis. 1923.

ABOUT seventeen years ago Col. Stephenson began to devote himself to the study of Indian earthworms. Laboring with extraordinary zeal, he published thirty-five papers, and described 126 new species and a number of varieties. He has now gathered all his results, combined with those of other workers, into a volume of 518 pages, treating the subject as exhaustively as the present state of our knowledge permits. This book is something more than a collection of descriptions of families, genera and species; it includes many reflections on the general aspects of the subject, on such topics as evolution and geographical distribution. It readily appears from a study of the tables and descriptions that specific (and even generic) characters have arisen by meristic variation in many instances. This variation is going on at the present time, as Beddard has well shown in the case of a common Indian species, *Perionyx excavatus* of E. Perrier. There is no reason why changes of this type should not occur independently in a number of places, and consequently doubts arise as to the phylogenetic integrity of some of the genera. The probable lines of descent have been worked out with some apparent accuracy, but the author has been led to suggest that of the large genus *Megascolex*, some species are derived from *Notoscolex*, others from *Perionyx*, and others probably from *Spenceriella*. Moreover, those derived from *Notoscolex* have had their origin "at different times and places." From such considerations one may be led, according to his bias, to either propose a series of new genera or lump those already recognized. By referring all these worms to a single

genus, it is possible to avoid the inconsistency of having polyphyletic genera, but only at the expense of considerable practical confusion. By going to the other extreme and dividing *Megascolex* into as many genera as there are probable lines of descent, we employ a logical method, but have before us a series of generic units which are extremely difficult to distinguish or define. We may suppose that posterity will on the whole prefer the second method, and will remove what would now be ambiguities by more intensive morphological and biological studies. In one case, Col. Stephenson states the dilemma very clearly. The genus *Plutellus* has given rise to a group called *Fletcherodrilus* by the fusion of certain paired structures. The morphological deviation is considerable, but if *Fletcherodrilus* is recognized, it has to consist of two species, which have arisen quite independently from *Plutellus* in India and Australia respectively. It is here assumed that *Fletcherodrilus* must be based wholly on the characters mentioned, but very likely some author will find other characters in the Indian species (*P. palniensis*), and will make it the type of a new genus.

It will be readily seen that the work is of interest to all biologists, whether they have occasion to study Indian worms or not. It contains a very excellent account of the general features of these animals, and full directions for their study. Were the reviewer possessed of adequate funds, he could think of no greater service than to make possible the publication of a Fauna of North America on the same lines as the Fauna of British India. We have the men who could write the volumes, given time enough. We certainly have the resources for publication, could they only be diverted into such productive channels. The volumes on the Indian Fauna, published by authority of the government, are reasonably condensed, yet full enough to supply the information desired. They are well printed and contain many illustrations. The style of publication is not extravagant and they are accordingly sold for a very moderate price. It is not unlikely that a North American series, thus conceived, would pay its way. It would, however, need an initial subsidy, as in the case of the much more condensed and far less adequate North American Flora, which is now or was recently self-supporting.

T. D. A. COCKERELL

UNIVERSITY OF COLORADO,
Boulder, Nov. 28, 1924

Maker, Man and Matter. Thread of Life Series I. By PIERSON WORRALL BANNING. International Book Concern, Los Angeles, California.

THIS is a volume of fantasy, purporting to deal with facts, of the type termed by Fechner, "cuckoos' eggs laid in the nest of science." It describes the development of the earth from the time when it was rolled out flat and inhabited by the first of the "four root races," invisible, boneless, sexless and ubiquitous, up to the year 7120 B. C. The period of the first root race (which followed the condensation of the whirlpool nebulae accomplished by electrons in the vortex of energy) lasted, we are told, 575,377,000 years. With the second root race, the hyperborean continent gradually extended towards the equator, forming, about 500,000,000 B. C., the continent of Lemuria inhabited 200,000,000 years by the third root race. The fourth root race began on the "lost Atlantis" nearly a million years ago, this continent breaking up, 100,000 to 200,000 years ago amid shocking episodes. It is to be succeeded by the new continents of Numeria and Nulantis, and so on. The book leans heavily on quotations from Blavatzky, Besant, Donnelly and other noted sciosophists treated as scientific authorities. Baron Münchhausen is, however, not even mentioned.

It is, in fact, an expanded fairy tale, conceived and told without genius or charm of any sort.

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SPECIAL ARTICLES

NOTES ON THE OLFACTORY AND OTHER PHYSIOLOGICAL REACTIONS OF THE CALIFORNIA HAGFISH[1]

POLISTOTREMA STOUTI is an interesting representative of the Marsipobranchii, the lowest of the vertebrates save amphioxus. The species is found in abundance in the waters of Monterey Bay and has held the interest of systematists (1), anatomists (2), morphologists (3), embryologists (4), and physiologists (5) since the opening of the Hopkins Marine Station of Stanford University in 1892 on the rocky Point Aulon on the south shore of Monterey Bay. No less than five young investigators of the station in the early years, all now prominent in science and in medicine, made extensive anatomical studies of the hagfish with drawings adequate for publication. Actual anatomical publication was first accomplished for the circulatory system by Dr. C. M. Jackson (2) under the inspiration of Professor Howard Ayers.

Nothing was known of the embryology of the hagfish until the eggs were found and identified in 1893. Even then many of the eggs obtained through an intelligent and shrewd Chinese fisherman, Ah Tak, were decomposed or partly digested. Ah Tak claimed

[1] From the Hopkins Marine Station of Stanford University and the University of Missouri.

that he obtained the egg specimens from the alimentary canals of the males. The first living embryos were secured by Professor Geo. C. Price. It was these specimens that afforded the basis for his classic papers on the development of the pronephros of the hagfish. Once it was known that eggs of the hagfish had been discovered in Monterey Bay morphologists came from near and far to secure them. Professor Bashford Dean (6), of New York, and Dr. E. Doflein (7), of Germany, came for hagfish embryos alone. The Chinaman Ah Tak levied heavily for contributions to his bank account, but the scientists thereby secured some priceless embryos out of many predigested and addled specimens (8). However, even now it is not fully known just when the hagfish spawning season is at its height nor how and where the eggs are disposed in the spawning act.

Physiologically the hagfish is extremely interesting. In the first place it is blind. There are rudimentary eye spots, but there is not the slightest recorded evidence of sensitiveness to light. The adult skin is continuous over the eye spots, though the area is characterized by the absence of skin pigment. The rudimentary eyes themselves are imbedded in pits in the cartilage of the head skeleton.

In compensation for the blindness, it would seem, there is great sensitiveness both to physical contact and to chemical stimuli. Observations show that when at rest the individual hagfishes habitually lie coiled in a spiral on the bottom of the aquaria and presumably on the sea bottom when free. They coil both clock-wise and anti-clock-wise, but always with the tail inside and the head on the outside of the spiral. This brings the nostril and the two short tentacles free to react to whatever may disturb. The slightest touch of the tentacles or of the skin about the head, however gently, produces the most prompt reaction. The head is withdrawn vigorously and for a distance of as much as one third to one half the length of the fish, which then immediately swims away. The reaction is equally prompt whether the hagfish is coiled and quiet or actively swimming about.

Contact with odorous substances is facilitated by respiration which is carried on by the musculature of the head and of the branchial pouches. These together act like a pump to draw water in at the one nostril and drive it out at the branchial pores or gill openings. A valve-like fold, a sort of soft palate, guards the posterior end of the nasal cavity, preventing a return of water through the inhalent nasal tube. It is assumed that this mechanism carries odorous particles to the olfactory apparatus. It is certain that the fish responds promptly and definitely to the presence of soluble chemical substances.

To test the olfactory reaction, a bit of food, a slice of sardine, was dropped into an aquarium, the bottom of which was covered with quiet and resting hagfishes. Instantly there was the greatest commotion. Hagfishes began to uncoil all over the aquarium. Those nearest the bait were most active. They swam at once along the trail through the water taken by the bait and seemed to search for it, apparently guided by chemical sense. When at last one individual came in contact with the bait the bait was seized and swallowed. When a whole sardine was offered to these hungry hagfishes, all in the aquarium were soon in active motion. The first to touch the bait at once rasped off the flesh by a quick movement of protraction and retraction of the corneous teeth of the mouth plate. Another individual by biting out the abdominal wall quickly bored or cut its way into the interior of the bait until several inches of the hagfish's head were buried. The rasping reactions continued until the flesh was removed from the skeleton of the bait. The entire reaction is a splendid illustration of the chemical guidance of a blind carnivorous and parasitic fish.

The impelling and far-reaching effect of this chemical tropism, for such it may be called, is well illustrated by our methods and the success in trapping the hagfish studied in this report. A five gallon tin oil can was punctured with a number of small holes just adequate to admit the passage of a hagfish. The roughened edges turned within acted to retard exit of the fish. A liberal amount of dead fish for bait was placed within the can through a trap door. The door was securely closed and the baited trap lowered to the bottom of the bay about one hundred yards off shore from the station. In the most favorable catch the trap was completely filled with hagfish. Some escaped during the drawing of the trap to the surface, but a total of sixty-seven specimens were secured from this one haul.

Incidentally, the number of hagfish attracted to this baited trap illustrates the difficulties of the commercial fisherman who undertakes to use set gear in Monterey Bay. The high percentage of netted fish lost by the destructive attacks of the hagfish have discouraged and destroyed set gear fishing (Jordan and Evermann (1)).

The California hagfish is one of the few animals that possesses more than one heart. It is known generally that the eels of the rivers of the Atlantic seaboard and of the Mississippi Valley have, in addition to the usual systemic heart, a contractile vascular organ in the tail on the caudal vein. The hagfish, however, has three hearts. One is the systemic heart in the usual relations to cardinal veins and ventral aorta. It has the anatomical structure typical of fishes. The portal venous system also has a heart

with incoming and outgoing vessels all adequately provided with valves to insure a one-way course of the blood (Jackson (2)). The third heart is the so-called caudal heart. This is a true pump supplied with valves and located at the beginning of the caudal vein. In fact, it is a bilaterally symmetrical or double heart, each half collecting blood and lymph from the subcutaneous sinuses of the corresponding side of the body (Greene (5)). The caudal heart varies from the systemic and the portal hearts in that the walls of the cavity itself are not contractile. The power that contributes the energy for the caudal pump is a pair of striated or skeletal muscles differentiated out of the great lateral muscles of the region. Like all skeletal muscles, these are controlled by spinal nerves and by a rhythm inherent in a definite spinal center (4, 5). In its coordinative nerve control the caudal heart of the hagfish is unique, for the portal heart and the systemic heart are both without nervous regulation (5).

There are still many facts of the biology and natural history of the hagfish to be determined. The living collections maintained at the Steinhart Aquarium of the Golden Gate Park in San Francisco may add to a fuller knowledge of facts. This blind primitive form is indeed replete with morphological, embryological and physiological interest to both student and investigator.

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CARBON MONOXIDE, A PRODUCT OF ELECTROLYSIS

PHOSGENE has for some reason always been regarded as a non-ionizing solvent, and this view was given support by the observation of Beckmann and Junker, in a study of the ebullioscopy of phosgene solutions, that organic acids dissolve in it as double molecules, while their anhydrides dissolve as simple molecules, a phenomenon that has been observed for non-ionizing solvents such as benzene.

The ease with which solutions of aluminium chloride in phosgene react with metals, metallic oxides, sulfides, carbonates, etc., however, led me to believe that these reactions were of the ionic type, and that the solutions contained ions and would therefore conduct electricity. The experiment verified the prediction, and conductivity measurements have shown that, while phosgene itself is a very poor conductor, the specific conductivity of the solution of aluminium chloride in phosgene increases with the concentration until the more concentrated solutions conduct nearly 100,000 times as well. Mr. Russell Timpany, working in this laboratory, has measured the conductivity of redistilled technical phosgene, and has obtained the value $.007 \times 10^{-6}$ for the specific conductivity at 25°.

The products of electrolysis were not collected separately, but the gases evolved from a cell connected in series with a copper voltameter were evolved under mercury, the surface of which became blackened, showing the presence of chlorine; a solution of sodium hydroxide, over the mercury, absorbed phosgene, which was present in the evolved gases by virtue of the vapor tension of the solution, and the unabsorbed residual gas was collected in a gas burette filled with sodium hydroxide. Analysis of this gas showed it to be carbon monoxide (characteristic combustion and absorption by cuprous chloride). The volume of the gas collected, however, was only 65 to 75 per cent. of the volume calculated according to Faraday's law from the weight of copper obtained.

This is undoubtedly due to the fact that carbon monoxide and chlorine in the light readily combine to form phosgene, so that under the experimental conditions employed a certain proportion of the gases evolved would inevitably recombine to form phosgene. Furthermore, Plotnikov has shown that when a mixture of these gases is bubbled through a solution of aluminium chloride in chloroform, the solution contains phosgene; it would seem reasonable to suppose that the same combination might occur in the presence of aluminium chloride in phosgene solution.

It has been shown, then, that phosgene is a weakly ionizing solvent and that when the solution of aluminium chloride in phosgene is electrolyzed, car-

bon monoxide and chlorine are evolved. The production of carbon monoxide by an electrolytic method is unique, as it has heretofore not been obtained by electrolysis.

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WHAT IS AN ACID?

IN terms of the theory of electrolytic dissociation, an acid is any substance which yields the hydrogen ion in water solution, and a base any substance capable of yielding the hydroxide ion under similar circumstances. But Franklin has shown that this definition of a base is too narrow, and that a comprehensive definition should include substances capable of yielding the amide ion in ammonia solution. The question may, then, be legitimately asked, if bases may include substances that do not yield the hydroxide ion, may there not exist acids that do not yield the hydrogen ion?

I have recently been forced to the conclusion that the answer to this question is in the affirmative. The evidence, which I shall discuss more fully in another paper, consists in the following facts. Aluminium chloride is very soluble in liquid phosgene, $COCl_2$, and several phosgenates of aluminium chloride have been described in the literature. I have shown that this solution conducts electricity and that the products of electrolysis are carbon monoxide and chlorine. I have also shown that this solution reacts with metals, with metallic chlorides, oxides, sulfides and carbonates to form compounds, containing the metal as chloride, and aluminium chloride, with phosgene of crystallization, and that carbon monoxide, carbon dioxide, carbon oxysulfide are split off.

These observations become intelligible if we assume that the active substance in the solution is a phosgenate of aluminium chloride, such as $2AlCl_3.COCl_2$, which may be compared with the behavior of $2SO_3.H_2O$, or with $SO_3.H_2O$ in water solution; it is customary to write $H_2S_2O_7$ or H_2SO_4 to represent the condition of the hydrates of sulfur trioxide, and in an analogous manner we are led to write $COAl_2Cl_8$ to represent the condition of the phosgenate of aluminium chloride in phosgene solution. This compound, carbonyl di-chloraluminate, reacts with metals to produce salts of the type $M^{II}Al_2Cl_8.xCOCl_2$ (using a bivalent metal as example), with liberation of carbon monoxide, in precisely the same manner as sulfuric acid produces, with metals, salts of the type $M^{II}SO_4.xH_2O$, with liberation of hydrogen. With metallic chlorides, carbonyl di-chloraluminate reacts to produce salts of the same type, splitting off phosgene, in precisely the same manner as sulfuric acid produces sulfates with the metallic oxides, splitting off water. The analogy may be carried on to the other reactions and to the electrolysis of the two solutions, and the conclusion becomes inevitable that these solutions have properties so precisely similar that we must classify them in the same group—in other words, carbonyl di-chloraluminate is an acid. But this acid contains no hydrogen; in its place, we have carbon monoxide. The metallic chlorides must be regarded as bases, and the chloride ion in these bases corresponds to the hydroxide ion among the aquo-bases, and to the amide ion among the ammono-bases.

What, then, is an acid?

First of all, an acid involves a solvent, and as far as we know an ionizing solvent—such as water, ammonia, phosgene, to mention only those we have referred to in this note. In the second place, an acid is a substance dissolved in the solvent, which is chemically combined with a portion of the solvent, as SO_3 is combined with water, as $AlCl_3$ is combined with phosgene, or as C_3N_4 is combined with ammonia (cyanamide, H_2CN_2, or di-cyanimide, $HN(CN)_2$). Finally, solutions of these acids in their respective solvents give certain definite reactions—they conduct electricity and the solvent is decomposed in the process; metals displace the ion common to the acid and the related solvent (H, CO, etc.) forming salts; they react with bases derived from the related solvent to form salts, splitting off a molecule of the solvent; etc.

In short, an acid is the substance formed when an ionizing solvent unites chemically with a suitable compound and is capable of forming salts with metals and with bases derived from the same solvent.

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MIOCENE MARINE VERTEBRATES IN KERN COUNTY, CALIFORNIA

PROBABLY the first vertebrate fossils collected in California were the teeth of sharks picked up by W. P. Blake, geologist of the Williamson contingent of the Pacific Railroad Survey, in 1853.

The original location was given as "Depot Camp" on the south side of Poso Creek (called Posé Creek in the original reports; also called Ocoya Creek and spelled Ocoga on the map) "Lat. 305° 30′ 27″, Long. 118° 53′ 02″," Kern County, California. The specimens were described and illustrated by L. Agassiz.[1]

[1] *Am. Journ. Sci. Arts,* 1856, pp. 272–275; Pac. R. R. Reports, Vol. 5, 1857, pp. 313–316, plate 1, figs. 1–44; for a full account of the occurrence of the specimens see pp. 164–173.